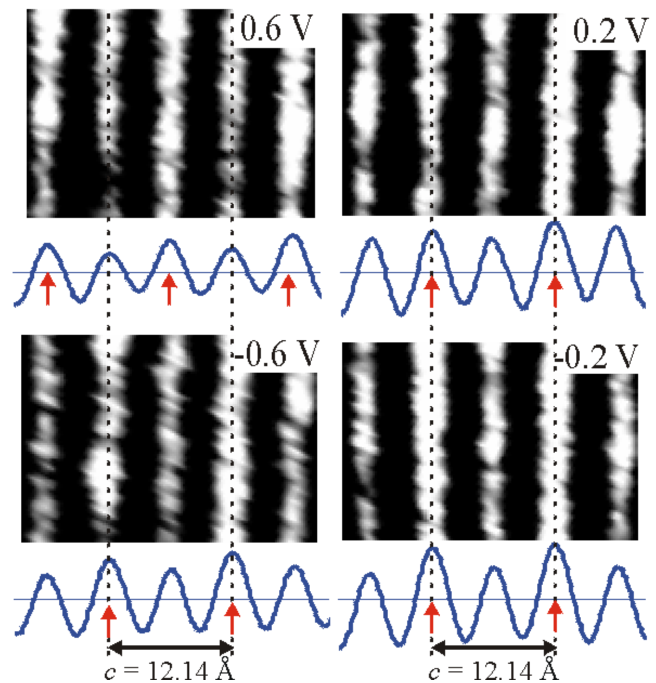
NIRT: Building Nanospintronic and Nanomagnetic Structures: Growth, Manipulation, and Characterization at the Atomic Scale

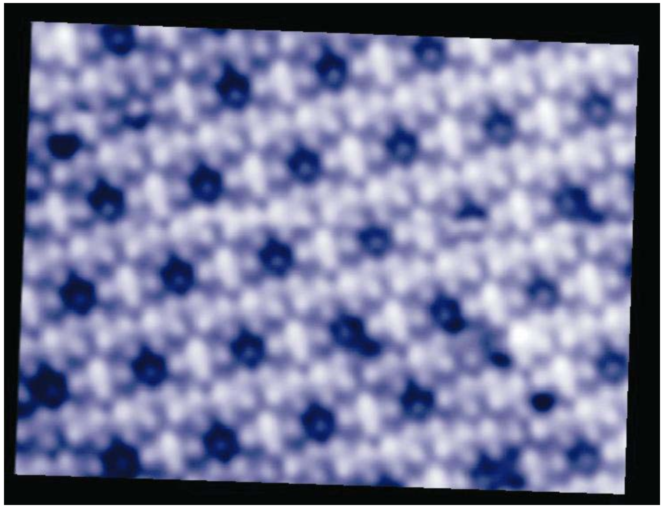
Arthur R. Smith, Saw-Wai Hla, Nancy Sandler, and Sergio Ulloa
Ohio University, Athens, OH, DMR-0304314.

Manganese Nitride



Atomic-Scale Spin-Polarized Scanning Tunneling Microscopy

The method of spin-polarized scanning tunneling microscopy allows to obtain spin contrast down to atomic scale. Shown at right are 4 images of antiferromagnetic Mn_3N_2 (010) acquired at different bias voltages. What is observed is that the spin contrast reverses between +0.2 and + 0.6 V. Thus, spin contrast can be "turned off" at ~ +0.4V. Red arrows indicate atomic rows with spin-↑, and those rows appear *higher* than in-between rows, which are spin- ↓ . PI *Smith* and his group are developing atomic-scale SP-STM as the method which can obtain the ultimate spin spatial resolution.



Self-Assembled Two-Dimensional Kondo Lattice

An ideal future application for atomic-scale SP-STM is in the measurement of the spin of self-assembled molecular (SAM) layers. We have succeeded to fabricate a SAM consisting of TBrPP-Co molecules. Each molecule contains one magnetic Co atom. The image, acquired at liquid He temperature, shows 3 TBrPP-Co molecules per unit cell of the surface and was acquired by the group of co-PI *Hla*.

NIRT: Building Nanospintronic and Nanomagnetic Structures: Growth, Manipulation, and Characterization at the Atomic Scale; Arthur R. Smith, Saw-Wai Hla, Nancy Sandler, and Sergio Ulloa, Ohio University, Athens, OH, DMR-0304314. The NIRT seeks to build magnetic structures 1 atom or molecule at a time on surfaces and investigate the magnetic and electronic properties of the nanoscale structures so formed. During the first NIRT year, PI Smith and his group have studied various potential magnetic and non-magnetic substrates as well as the technique of UHV atomic-scale spin-polarized scanning tunneling microscopy (SP-STM). This technique is crucial to the future ability to utilize the STM tip to measure the magnetic properties of nanostructures. It has been found that the energy-dependence of the SP-STM technique allows one to turn the magnetic contrast "on" or "off," further improving the utility of the method.

In addition to building 1 atom at a time, Hla and his group are also exploring methods of self-assembly to form ordered magnetic nanostructures. The image shown here depicts a self-assembled monolayer of TBrPP-Co molecules, each of which contains 1 magnetic atom. The superstructure so formed comprises a two-dimensional "Kondo lattice," an entity not well known up to now. Kondo phenomena are derived from spin-electron interactions. One of the goals of our research is to understand better such interactions. The results obtained so far this year have made a giant step forward in this direction.

NIRT: Building Nanospintronic and Nanomagnetic Structures: Growth, Manipulation, and Characterization at the Atomic Scale

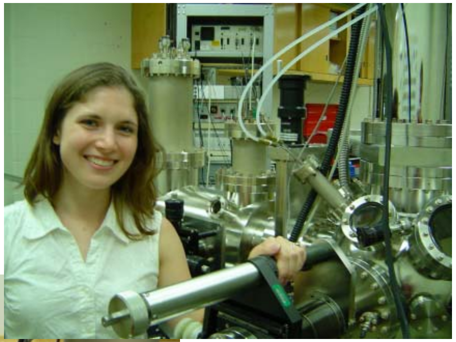
Arthur R. Smith, Saw-Wai Hla, Nancy Sandler, and Sergio Ulloa
Ohio University, Athens, OH, DMR-0304314.

Education in Collaborative Nanoscience Research. In total, ~18 undergraduate, graduate, and postdoctoral researchers are gaining experience working on NIRT-related projects. These projects range from laboratory construction to experimentation to manuscript preparation. PI and co-PIs are engaged in implementing a highly interdisciplinary learning environment spanning from sample preparation to characterization to application of theory.

Undergraduate student Joel Vaughn constructing a manipulator head.

UHV-LT-STM system constructed for the NIRT project

Anita Martin next to the MBE chamber →



Sarah Laubacher by the STM chamber ←

Nanoscience Writers in the Making. The NIRT is engaged in the training of writers in nanoscience in tandem with the highly regarded *Scripps School of Journalism* at Ohio University. During Year 1 of the grant, 2 senior undergraduates took part in the training, shown at left. Each student produced 4 written pieces on nanoscience which are distributed through our new NIRT website http://www.inventure.com/nsnm/web/. Three of the 4 pieces are written in tutorial style and form the first of our "spintorials" which are aimed at a high school audience.

NIRT: Building Nanospintronic and Nanomagnetic Structures: Growth, Manipulation, and Characterization at the Atomic Scale; Arthur R. Smith, Saw-Wai Hla, Nancy Sandler, and Sergio Ulloa, Ohio University, Athens, OH, DMR-0304314. The broader impacts of this NIRT are several-fold. First of all, significantly high degrees of learning are being provided for the 18 students and postdocs which have worked on activities related to the NIRT. Since these students come from different labs, it results in good collaborative learning. Secondly, the NIRT has provided opportunities for the training of Journalism students to become nanoscience writers. So far, 2 undergrads from Ohio University's renowned *Scripps School of Journalism* have taken part in the program, each producing 4 written pieces this year. Each year of the NIRT, it is intended that 1 or 2 new writing students will take part in the program. Thirdly, the NIRT has planned the development of its own Nanospintronics and Nanomagnetics website, which is now being completed (see http://www.inventure.com/nsnm/web/). This site has both research and educational components, including sections for "research news," "spintorials," "demos," "hot topics," and a "nano gallery." A significant portion of the site is intended for a high school/lay audience. As a 4th component of our teaching/outreach efforts, K-12 teachers will ultimately be able to "request" a PI/co-PI visit to their school through the website. During the first year, NIRT members visited several K-12 schools and made a number of presentations, including to an entire Junior High School during its "Career Day." During that visit alone, some 160 students were reached.